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Erosion Control
in Ohio Farming

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Strip Cropping in Muskingum Co.

Contents

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Erosion Control in Ohio Farming

NO NATION in the history of the world has long survived on depleted soils. History records the fall of many nations and, in practically all, men of vision have at the time recognized impoverished soils as a chief contributing cause. America is no exception. Agriculture moved westward to virgin lands, leaving ruined soils to the east. Thousands of farms and millions of acres have been abandoned. Soil erosion has been a heavy contributor to this. In the earlier days of American agriculture, the impression prevailed that land was without limit, and that it was the function of the farmer to turn natural productivity into a living for his family.

JUNE, 1935
Planted area fenced from pasture.

SEPTEMBER, 1937
Tree growth of three growing seasons.

Fig. 1.—Trees are the most effective means of erosion control. The erosion on the permanent pasture at left was controlled by protected locust-tree planting, as indicated on the right.

For thousands of years these virgin soils had been in the process of formation, and farmers, through devastating practices, destroyed in a few years the accumulated product of this long period. In recent years there has been a general realization that new lands are no longer available, and that farming must be so organized that it can continue indefinitely upon the same land. This has brought to public attention the enormous losses due to soil erosion, and the tremendous job ahead in organizing American agriculture on a permanent basis. While only recently has the subject appeared so prominently in the press, it has long been recognized as a vital consideration to permanent civilization.

As early as George Washington's time the problem had become acute in eastern Virginia, and much of his time in the last years of his life was devoted to reorganizing his farm practice so that the devastating effects of soil erosion might be checked.

The problem is now acute in Ohio. This bulletin is written for the purpose of bringing more clearly to the attention of all persons interested in the future of Ohio some facts concerning the rapid depletion of our greatest natural resource, our soil, and how it can be conserved through intelligent farm practice. Soil productivity is a natural resource, essential to the maintenance of a perma-

nent civilization. It is entrusted to farmers for their use, but not for them to destroy.

Conservation of the soil is a public responsibility that concerns not only the farmer, but it is a problem that should have the attention of every patriotic and far-seeing citizen of the state.

Types and Extent of Soil Erosion*

SOIL EROSION is caused by the action of water or wind moving over the surface of the land, thereby transporting particles of soil from one place and depositing them in another. The point of deposition, however, may be many miles from the original position.

In Ohio, we are concerned chiefly with water erosion on the uplands in the form of sheet erosion, gullies, and landslides; and on the bottom

Fig. 2.—A combination of sheet and gully erosion. This is an ominous illustration of what can happen in a few years without a vegetative cover. The picture was taken near Duckton, Tennessee, where fumes from a copper plant had destroyed the plant life. *(Courtesy P. B. Stockdale.)*

lands in the form of depositions and stream channel damage. These are discussed on the following pages.

Types of Erosion

Sheet Erosion.—This is the removal of soil more or less uniformly from the surface of the land. Because of this uniform removal, very heavy losses usually take place without being observed. One of the outstanding evidences of such erosion is the so-called "galded" spots frequently observed in fields. A further

* For a more detailed description of erosion in Ohio, see Ohio Agricultural Experiment Station Bulletin No. 589.

evidence is the gradual change in color of the soil in the plow layer caused by the plowing up and exposure of more subsoil. These effects are well illustrated in Fig. 7, where it may be observed that the vegetative cover has disappeared and the soil has assumed a light color instead of the original brown.

Gullies.—A gully is a channel cut into the soil by water to such a depth that it cannot be filled by ordinary cultivation or plowing. In Ohio, gullies rarely occur except on those lands which have lost the greater part or all of the topsoil. Gully erosion, as illustrated in Figs. 1 and 32, thus represents the final stage of land destruction by erosion. While gullying is the most evident phase of erosion from the standpoint of soil deterioration, it is of much less importance than sheet erosion.

Slips or Landslides.—These result from the movement downgrade of large masses of land. Water and gravity are the main contributing factors. An impervious layer of rock or soil will stop the downward percolation and thus cause water to accumulate. Eventually the lower part of the overlying soil becomes saturated to the point where it will flow, thus causing slips and landslides (see Fig. 3).

These slips occur chiefly on steep hillsides where the soils have a fine or claylike texture.

Fig. 3.—A landslide in Noble County. Slips like this are frequently the beginning point of serious erosion on steep land.

Extent of Erosion in Ohio

The extent of erosion in any region varies with differences of soil, slope, and cover. Fig. 4 shows in a general way the conditions in various parts of Ohio. The meaning of the terms used in the legend of this map is as follows:

1. Little or no erosion — less than 25 per cent of surface soil removed.
2. Moderate sheet erosion — from 25 to 75 per cent of surface soil removed.
3. Severe sheet erosion — over 75 per cent of the surface soil removed.
4. Occasional gullies — an average of 3 gullies or less per acre or gullies 100+ feet apart.
5. Frequent gullies — an average of more than 3 gullies per acre or gullies less than 100 feet apart.

Southeastern Ohio.—The sloping lands of southeastern Ohio are highly erosive if cleared of their natural forest and put under cultivation.

Over much of the hilly to rolling lands of Lawrence, Gallia, Meigs, Jackson, Vinton, Athens, Hocking, and parts of Morgan and Washington

Counties, sheet erosion is moderate. Severe sheet erosion is common on the steeper slopes that have been continually farmed. Frequent gullies occur on heavily cropped areas, especially on soil derived largely from shale. Elsewhere in this section there are only occasional gullies.

An area in Scioto, Pike, Ross, and parts of adjoining counties includes some of the roughest lands of the state, but shows a small amount of erosion. Much of this area has not been cleared and only a small percentage is used for crops. Excessive erosion is confined largely to the small areas of cultivated lands.

Severe sheet erosion accompanied by occasional gullies is common over much of the land east of Knox, Licking, and Fairfield Counties and between Marietta and the northern Jefferson County line. This region is the most developed agriculturally of southeastern Ohio. About 70 percent has been cleared of its timber growth and utilized for farm crops. Nearly all lands used for crops have lost at least three-fourths of their topsoil. Lands that earlier were cropped but more recently retained in pasture have suffered considerable damage except where a good cover has been maintained. Even some woodlands, especially those

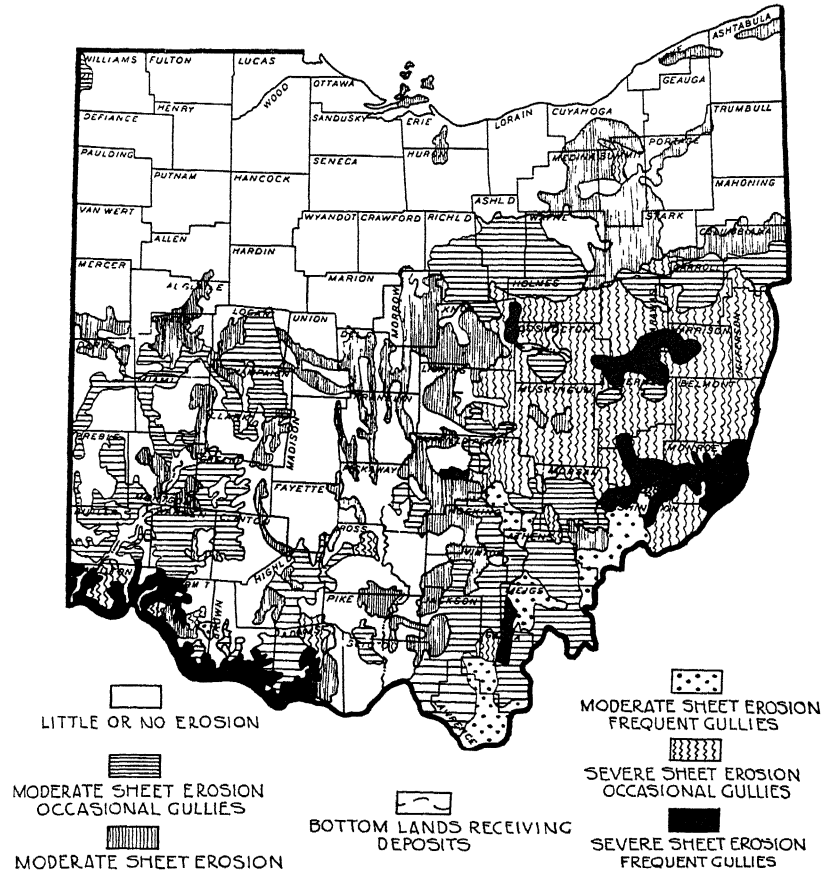

Fig. 4.—Extent of soil erosion in Ohio. See pages 5 to 9. *(Courtesy Soil Conservation Service.)*

that are pastured or are affected by frequent burning, show evidence of severe sheet erosion.

Frequent gullies occur in Monroe, Washington, and Tuscarawas Counties. Here, as farther south in the state, the gullies are usually on soil derived largely from shale. These shale soils are especially subject to damage by erosion and unless a good cover is maintained they are rapidly destroyed.

Northeastern Ohio.—The topography of northeastern Ohio is much smoother than in southeastern Ohio, so the land is not as greatly affected by erosion. A considerable area, especially in northern Mahoning, Trumbull, Ashtabula, Geauga, and Lorain Counties, where the land is undulating to nearly level, shows little or no erosion. The small amount of erosion present is confined chiefly to the breaks near streams.

The more rolling lands in southern Mahoning, Geauga, Summit, and Medina Counties, and in Columbiana, Stark, Portage, Wayne, Ashland, and

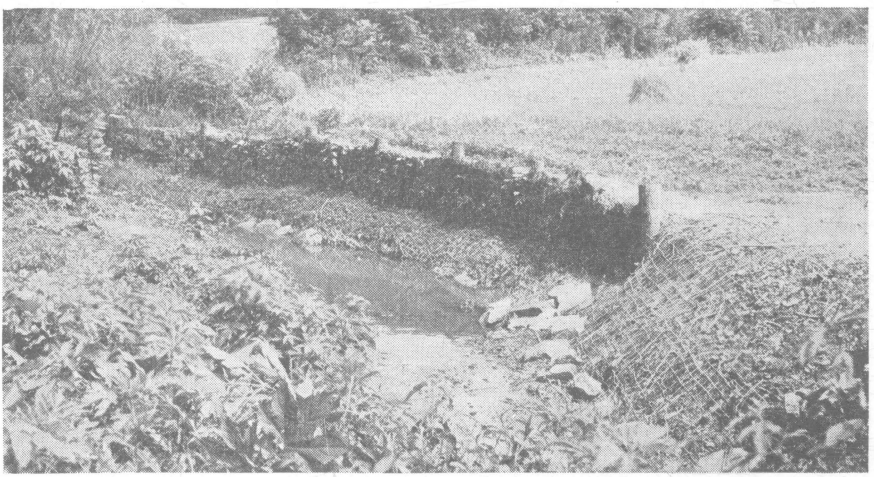

Fig. 5.—Stream bank control. Valuable bottom land is frequently destroyed by shifting of the stream channel. *(Courtesy Soil Conservation Service.)*

Richland Counties, show a moderate amount of erosion. Here the topography is variable, with much sloping land. Nearly all these slopes have lost from one-fourth to one-half of their topsoil through sheet erosion. Occasional gullies occur in Wayne, Ashland, and Richland Counties, where the slopes are longer and where there is a relatively high percentage of cultivated crops.

Northwestern Ohio.—Northwestern Ohio is nearly free from erosion except on the rolling lands in western Williams County and on the gently rolling lands of Ottawa, Erie, and Huron Counties. Here the erosion occurs as sheet losses on cultivated lands wherever the slopes are sufficiently long or steep to cause rapid runoff of water in heavy rains. Small amounts of sheet erosion also occur on the steep breaks along stream courses.

Western Ohio.—Western Ohio from the Darke-Mercer line to the Hamilton County line and east to Fayette, Madison, and Union Counties is

marked by areas with moderate sheet erosion and by other areas with little or no erosion. This is a highly developed agricultural region with large acreages of cultivated crops such as corn and tobacco. Hence a large proportion of the land surface is exposed to the action of water during the year. This leads to losses by sheet erosion on all lands that have even a slight degree of slope. Much of the land along the Miami River and its tributary streams and in central Logan County has lost one-fourth to three-fourths of its topsoil. Occasional gullies accompany sheet erosion throughout the region.

Central Ohio.—Central Ohio from Union and Morrow Counties and south to Fayette and Pickaway Counties is undulating to nearly level land. Slopes occur near streams and it is here only that moderate sheet erosion occurs. Gullies are rare in the region.

Fig. 6.—Heavy erosion losses result not only from washing of upland but also from the covering up of good soil with poor subsoil and stone and the destruction of crops on leval land at the foot of slopes and along streams. *(Courtesy Soil Conservation Service.)*

Southwestern Ohio.—Southwestern Ohio possesses a wide variety of erosion conditions. The nearly level lands in Clermont and Brown Counties show little sheet erosion except on the slopes near streams. Many of these areas have lost nearly all their surface soil, although the total area so affected is small. The rolling lands in Adams and Highland Counties have large acreages suffering from moderate sheet erosion. Lands used for cultivated crops have lost about one-half of their topsoil. Occasional gullies accompany sheet erosion in this region.

The rolling ridge tops of Hamilton County during years in cultivation have been severely damaged by sheet erosion. The soil is very erosive and in its present condition is not adapted to the production of a good vegetative cover.

The most severe sheet erosion and the greatest amount of gullying occurs on the steep hillsides bordering the Ohio River. Nearly all the surface soil has been lost from these steep slopes. A large part of these lands has been cleared, and has been cropped for a time for production of tobacco and corn. This resulted in a very rapid erosion. With loss of the topsoil, the fine textured subsoil has been exposed and eroded rapidly with the formation of frequent gullies. As a result, all slopes are denuded of surface soil and scarred by frequent gullies.

Indirect Losses Due to Erosion

While the main losses resulting from erosion are to the lands eroded, there is another extensive damage in the way of bottom lands and bottom land crops that are covered up (see Fig. 6).

Silt is frequently deposited on crops on the flood plains of the small streams of Ohio. Some of the larger streams also deposit silt on their flood plains during

Fig. 7.—Before gullies develop, the chief erosion losses occur as sheet erosion due to short rotations and low productivity level. Note complete removal of surface soil in picture, as evidenced by the light spots of subsoil without vegetation.

periods of high water. This is noticeable along the Scioto River below Chillicothe, along the Walhonding River in Coshocton County, along the Muskingum River in Muskingum and Washington Counties, and along the main course of the Miami River. The heaviest silt deposits occur along the lower Scioto, where it is not uncommon for 2 or 3 inches of soil to be dropped each year.

Formerly, this sediment had fertilizing value. In recent years in many areas where erosion has been severe in the uplands, the sediment is largely unproductive subsoil and results in a reduced productiveness of the bottom lands.

There are also many instances along both large and small streams where valuable bottom lands have been destroyed by shifting of stream channels. This frequently can be prevented by protecting the bank by means of stone, posts, the setting of willows, or the staking in of sections of wire fence (see Fig. 5).

Causes of Soil Erosion

Land Use

IN THE EARLY HISTORY of American agriculture, soil manipulation was done with very simple implements. These could be used on steep land about as easily as on level land and, since all lands were relatively productive, and since the need for soil conservation was not recognized, no attempt was made to limit the use of any lands to such purposes as would best conserve their productiveness. The same crops, the same rotations, and the same cultural practices were used everywhere. Consequently, much damage eventually resulted.

Experiment Station tests have shown that sloping land in ungrazed woods loses an insignificant amount of water and soil in the runoff during and immediately following ordinary rains. When such soil is covered with a good bluegrass sod the losses, though greater, are still so little as to be unimportant. When such land is in general field crops, the losses are still heavier and present a real problem in soil conservation, especially where cultivated crops occupy one-third or more of the rotation. Under such conditions 25 per cent or more of the annual rainfall may never enter the soil but flow off immediately, taking with it many tons of soil. A study of results obtained at the Northwestern Appalachian Soil and Moisture Conservation Experiment Station, and a reconnaissance survey of erosion conditions in Ohio indicate the approximate and relative soil losses on slopes of 12 to 15 per cent or less for different conditions indicated in Table 1.

Table 1.—Approximate Annual Soil and Water Losses per Acre in Ohio with Different Types of Vegetative Cover on Moderately Sloping Land.

Land Use	Annual Loss per Acre		Years required to erode surface 7 inches of soil*
	Percent of rainfall in runoff	Tons of soil	
Woodland (unpastured)	0 – 5	Trace	....
Good bluegrass sod	5 – 10	Trace	....
Good legume-grass meadow	12 – 18	0.1 – 0.2	5200
Poor clover-timothy meadow	16 – 24	0.5 – 0.75	1400
Wheat in rotation	22 – 37	6 – 10	105
Corn in rotation	20 – 30	30 – 45	20
Continuous corn	35 – 45	65 – 85	12
Continuous corn on badly eroded soil	35 – 45	80 – 105	10

* Calculation: 1 acre-inch of soil equals 150 tons.

While there exists wide difference in the effect of various types of cover on the percentage of runoff and soil loss, there is also a great variation between rains and different soil slopes with the same type of cover. Unproductive soils erode twice as fast as productive ones, and cultivated land a hundred or more times as rapidly as land in good sod.

It has frequently been observed that where the soil is evenly plowed to the proper depth and well pulverized and carefully cultivated, water run-off and soil loss are much less than where the soil is plowed to an insufficient depth, poorly pulverized, and carelessly cultivated. Likewise, experiments have shown losses to be much heavier where plow and cultivator furrows run up and down the hill rather than on the contour, and where the vegetative cover is light compared to where it is heavy. Failure to recognize these facts in the past has been another factor contributing to the general destruction of the soil.

In the beginning of our agriculture, farms and fields were laid out as squares or rectangles rather than on the contour. Consequently, a type of culture suited to erosion control was very frequently impossible even though it might

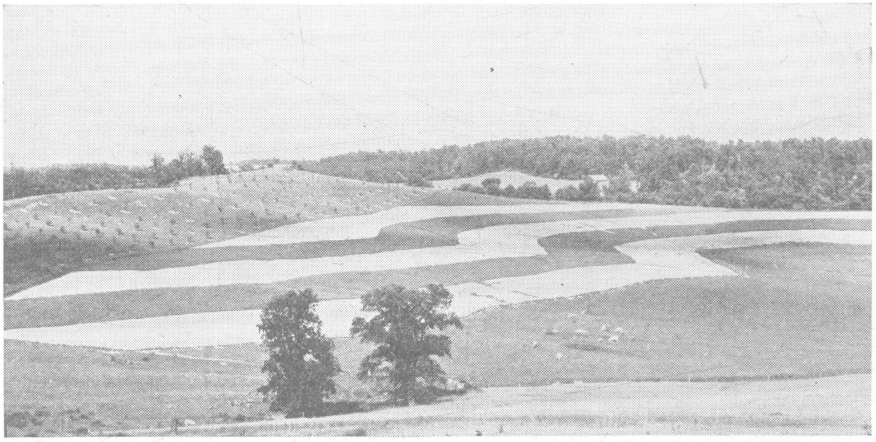

Fig. 8.—An illustration of wise land use. Orchard at top of slope, strip covering on the more gentle slope through the center, and permanent pasture on the steeper and irregular land further down which is also subjected to the flow of extra water from above. *(Courtesy Soil Conservation Service.)*

have been desired. Great pride was taken in straight corn and fence rows and the planting of a single crop to an entire field. Rotations consisting largely of cultivated crops were used, and very generally plowing and cultivating was up and down the hill rather than on the contour. Insufficient soil cover was provided and soil productivity declined.

Had the degrading effects of these practices followed immediately after their use, the practices might have been changed; but the evil results showed up so slowly that no attention was given them except by a few, far-seeing individuals such as Thomas Jefferson and George Washington. While these men and a few others took some definite steps in the direction of erosion control, generally nothing was done. All of which tended to hasten the depletion of the soil and increase the erosion.

Means for Erosion Control

LAND USE

NOW THAT the problem has become serious on so many Ohio farms, means of control must be inaugurated. First among these control measures is getting each area into that use to which it is best adapted and by means of which the soil may be conserved (see Figs. 1 and 8). There can be no hard and fast rule, but the following classification may be used as a general guide:

Adapted Use	*Types of Land*
FARM WOODS	1. Badly eroded lands. 2. Land too rough or irregular to be gotten over with the machinery necessary to maintain it in permanent pasture. 3. Limestone soils with slopes of 40 percent or more. 4. Sandstone and shale soils with slopes of 30 percent or more. 5. Lands not conveniently located for other use.
PERMANENT PASTURE	1. Sandstone and shale soils with slopes of 18 to 30 percent. 2. Limestone soils with slopes of 20 to 40 percent. 3. Lands subject to excessive flood damage if farmed in general field crops. 4. Other more level lands not required for general crop production.
GENERAL CROP LAND	1. Level lands not subject to excessive flood damage. 2. Sloping lands up to the limits mentioned under pasture in so far as they are required for a well balanced livestock production program on the farm.

On many farms there is insufficient land with a slope of 18 per cent or less to meet the crop requirements. Under such conditions these general rules should be approximated as nearly as possible, and other control measures used as carefully and extensively as is practicable.

For example, one farm may have no land available for crops with a slope of less than 25 per cent, but, by means of a 4- or 6-year rotation including 2 or 4 years sod, a high productivity level, strip cropping, etc., the soil may be fairly well conserved. In fact, one farmer may crop land with a 25 per cent slope and conserve his soil better than another who is cropping a 10 per cent slope.

The use to which the various slopes are devoted in a practical system of farming may vary widely from the slope classes previously mentioned, depending upon the type of farming and the needs for livestock feed on the farm, and the ability of the farmer to inject extra conservation methods into a system that might otherwise be ruinous. With dairy cattle or sheep, or raising of beef calves, large amounts of pasture and hay are required; while with hogs or beef feeder cattle, comparatively small amounts of pasture and hay, but large amounts of grain are needed. The use to which the land is put will, therefore, vary with the type of farming as well as with its natural adaptation.

EROSION CONTROL ON CROP LAND

Soil and Crop Factors.—In the use of sloping land for general crop production, it is important to keep in mind that the chief factors contributing to soil erosion are:

1. Steep and long slopes especially when the entire slope is plowed at one time.
2. Low productivity levels (see Figs. 2 and 12).
3. A large proportion of intertilled and grain to sod crops in the rotation (see Figs. 7 and 11).
4. Plowing and cultivating up and down the slope rather than on the contour (see Fig. 9).
5. Leaving the land exposed without vegetative cover (see Fig. 2).

The erosion control practices best adapted to each farm must be worked out individually for that farm.

Economic Factors.—While soil conditions will in the long run determine what crops can be grown and what livestock enterprises can be followed, the income of the farm family in the immediate future must also be considered. Therefore, in determining what practices, what crops, and what rotations can be used, economic as well as agronomic factors must be taken into consideration.

In a cash-crop system of farming, chief consideration may be given to the production of those crops for which there is a feed and market demand and which will give the largest return above cost of production. This implies, of course, that the rotation will be such as will maintain soil productivity balance and reduce

Fig. 9.—Plowing and cultivating up and down the hill, even though the slope is very gentle, may cause erosion loss amounting to many tons of soil in a single rain. Strip cropping and contour cultivation would have avoided most of the soil loss seen in this illustration. *(Courtesy Soil Conservation Service.)*

erosion to a minimum, with the thought that a good income may be obtained over an extended period of years as well as in the immediate future.

In a livestock system of farming, the selection of the rotation will be affected by the needs for livestock feed on the farm and the relative cost of producing digestible nutrients in various crops. Digestible nutrients can generally be produced more cheaply in legume hay than in any other rotation crop. The legume hays are followed in turn by non-legume hays, corn, and small grains.

Maximum use should be made of legume hays, while the acreage of corn and small grains should not be larger than necessary. On a hog farm, a 3-year rotation of corn, small grain, and hay, though not well adapted to erosion control, may be most desirable. However, whether or not it can be used will eventually be determined by whether or not sufficient extra precautions can be introduced to overcome the natural destructive tendency of this system. On a dairy farm, a 4- or 6-year rotation containing two or four years of hay may fit the needs better, and with it erosion control becomes comparatively easy.

The Meadow

From the point of view of erosion control and the maintenance of soil productivity, hay is the most important crop in the rotation. Special effort should be devoted to the development and maintenance of close growing, high yielding hay crops. Generally, alfalfa-grass mixtures are the best meadows for erosion prevention. With proper lime and fertilizer applications and with proper seeding methods, these mixtures may be very generally grown on lands subject to erosion.

Fig. 10.—Twenty years ago this Belmont County land was near ruin as a result of erosion. Today with strip cropping, good fertility practices and alfalfa-timothy meadows, erosion is no longer a problem.

It is a mistaken idea that alfalfa cannot be widely grown in eastern Ohio (see Fig. 10).

Lime, Fertilizer, and Manure.—Insufficient lime has been the chief factor responsible for poor meadows in eastern and southern Ohio. The production of satisfactory meadows on all farms in these sections would require probably four to six times the amount of lime now being used in the area. The use of lime must be accompanied with liberal fertilization, but too much emphasis on the importance of lime is not likely. A fertilizer program is outlined in Table 2 and need not be repeated here. The farm liming program should make provisions to have all general crop land on the farm limed sufficiently to grow alfalfa-grass mixtures within the next five years.

Since the farmer is interested in the earliest possible return on his invest-

ment, the next field to be seeded down should be limed first. The lime may be applied in connection with the preparation of the land for wheat, corn, or oats, which might come ahead of the wheat crop. The application may also be made on the corn land after planting and then incorporated by the following cultivations.

Once a liming program has been established there is little difference in the returns resulting from the different times of applying lime, and the matter of convenience and economy of application should have first consideration. Under such conditions lime may well be applied to the sod land next to be broken.

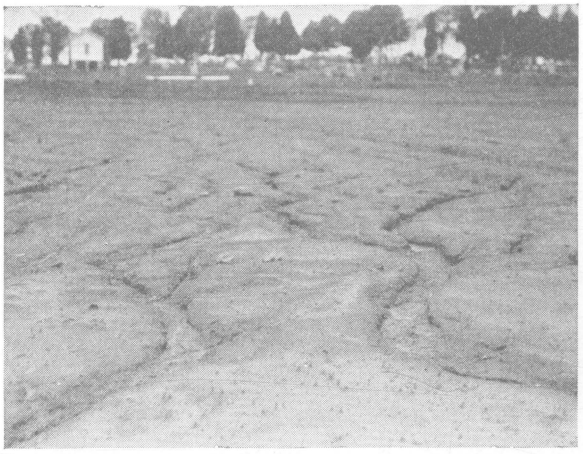

Fig. 11.—This field was prepared for a late summer seeding which was not made. The picture was taken the following April and illustrates the importance of a protective cover crop. This also indicates what frequently happens in the summer when land is prepared for seedings at that time.

New Seedings.—Since the soil should be covered during the winter, meadow seedings will generally be made with winter grains (see Figs. 11 and 12). Three pounds of timothy per acre should be seeded with wheat or rye in the fall. Should seeding be delayed till spring, 5 to 6 pounds will be needed.

The alfalfa and clover, totaling 10 to 12 pounds per acre, should be seeded in the early spring.

In southern Ohio, instead of timothy, orchard grass at the rate of 5 to 8 pounds per acre may be seeded in the spring in connection with the alfalfa and clover. It is more difficult to establish but is more persistent than timothy. It generally does not do well when seeded in the fall.

Brome grass is another grass worthy of trial at a rate of 5 to 10 pounds per acre in combination with timothy and alfalfa or clover. Some suggested seed mixtures for different conditions are contained in Table 2.

Fig. 12.—Leaving corn fields without a protecting cover crop may result in heavy soil losses. This is particularly true of badly depleted soils. Note the even removal of soil on most of the area.

Topdressing with Manure.—Winter topdressing of the small grain with manure, especially on the thinner, exposed areas, is very helpful in establishing new seedings, and may be considered as a standard practice. Where the land is not very productive and where manure applications do not exceed 8 tons per acre, all the manure in the rotation may be used in this manner rather than in the more usual way of applying it to sod land before corn.

Summer Seedings.—In emergencies, when spring seedings have failed, summer seedings should be made rather than leave the land bare over winter. This will require a fine, firm seedbed prepared at least two or three weeks before seeding to permit of accumulation of available nutrients and moisture. The new

Fig. 13.—Good meadows are essential to erosion control on sloping crop rotation lands.

seeding should be liberally fertilized, and made during July or August and when there is ample moisture to start the new crop. A very successful procedure on sloping lands has been to complete the preparation of the seedbed by use of the cultipacker, then broadcast or drill the seed, and repeat with the cultipacker on the contour. Summer seedings following a recently harvested grain crop may fail, due to insufficient moisture or failure to observe the above conditions. A topdressing of manure applied at once following seeding has been found very beneficial.

Duration of Meadow.—Once the new meadow is established it is desirable to hold it for two or more years or until the necessity for corn compels breaking. In order to utilize the extra meadow, the amount of grain in the livestock ration may be reduced, the amount of legume-grass hay increased, or silage be made

from the legume-grass meadow. This has been shown to produce meat and milk at a lower cost than when a heavy grain ration is used. The second and third crops of alfalfa-grass may be used for pasture. These come on in July and August when there is a general pasture shortage, and produce a cheap and excellent midsummer pasture.

Eroded and Runout Soils.—Even though sufficient lime is applied, alfalfa or alfalfa mixtures will not produce a satisfactory stand or yield on badly run-down and eroded soils. Such fields should be both limed and fertilized, and seeded to a very limited amount of alfalfa in combination with sweet or other clovers and grasses, and farmed well for one or two rotations in preparation for heavier seedings of alfalfa. Farming well means the use of other erosion control

Fig. 14.—Applying limestone and manure in a single operation. Maintaining a high productivity level is one of the most effective means of erosion control. Lime is a first essential. *(Courtesy Soil Conservation Service.)*

practices such as strip cropping, winter cover, sufficient lime and fertilizer, an abundance of manure, and the plowing under of good sods.

Where the land is not needed for other crops, it may be left in sweet clover and grass for from 4 to 6 years. During this time some grazing may be practiced, but not sufficiently heavy to keep the sweet clover from reseeding.

Rotations

To summarize these statements and give specific suggestions for the other crops in the rotation, three 4- or 6-year rotations adapted to land subject to erosion are given in Table 2. These are only suggestive, however. Other rotations better suited to particular conditions may be worked out after the same manner.

In the rotations listed in Table 2, oats and soybeans are not mentioned. Oats, however, is understood to be included under "other grains." Where oats is felt to be a necessity in connection with other farm enterprises, it is suggested

Table 2.—Three Recommended 4-Year Rotations for Land Subject to Erosion

All meadow seedings to be established in connection with grain crops of the second year.

A. For Land Adapted to Alfalfa — pH 6.5 to 7.0

Year	*Crop*	*Manure*	*Fertilizer†*
1st	Corn	6 tons on sod before plowing	150 lbs. in hill, or 200 lbs. in row
2d	Wheat or other grain	*4 tons as topdressing on winter grain	*400 lbs.
3d	Alfalfa-timothy meadow: Alfalfa, 8-12 lbs. in spring Timothy, 3 lbs. in fall, or 6 lbs. in spring	.....	.....
4th	Alfalfa-timothy meadow	.....	.....

B. For Land Moderately Adapted to Alfalfa — pH 5.8 to 6.4

1st	Corn	6 tons on sod before plowing	150 lbs. in hill, or 200 lbs. in row
2d	Wheat or other grain	*4 tons as topdressing on winter grain	*400 lbs.
3d	Alfalfa-clover-timothy meadow: 4-6 lbs. alfalfa in spring 4 lbs. red clover in spring 2 lbs. alsike clover in spring 3 lbs. timothy in fall, or 6 lbs. in spring	.....	.....
4th	Alfalfa-clover-timothy meadow	.....	.....

C. For Land Not Adapted to Alfalfa — pH 5.2 to 5.7

(Lime to A or B levels as soon as possible)

1st	Corn	6 tons on sod before plowing	150 lbs. in hill, or 200 lbs. in row
2d	Wheat or other grain	*4 tons as topdressing on winter grain	*400 lbs.
3d	Clover-grass meadow: 5 lbs. red clover in spring 3 lbs. alsike clover in spring 3 lbs. timothy in fall, or 6 lbs. in spring 1 lb. redtop in fall, or 2 lbs. in spring	.....	.....
4th	Clover-grass meadow	.....	.....

*** Indicates the manure and fertilizer applications that are most vital to success.**

† See Extension bulletin 136, "Fertilizers for Field Crops," for analysis and details of fertilization.

that the common rotation of corn, oats, wheat, hay be modified to omit the wheat and make the meadow seeding with the oats. Where oats is not a necessity it may be omitted and the seeding made with wheat. Wheat is commonly the more profitable crop. Where soybeans are a necessity to other farm enterprises they should replace corn and be removed in time for seeding wheat or other winter grain. Where the meadow is to serve as rotation pasture in the later years, it is advisable to include ½ pound of Ladino clover.

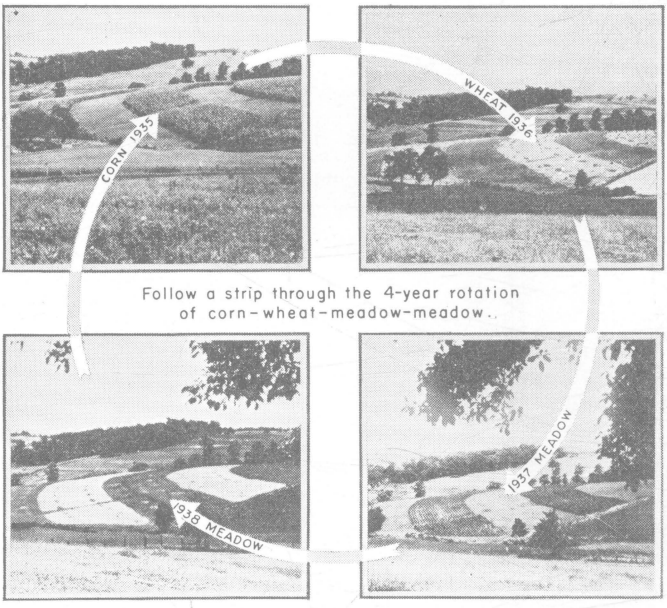

Fig. 15.—How crops rotate in contour strip cropping.

These rotations may be raised from 4- to 6-year rotations by making an application of manure and superphosphate following the removal of the second year meadow crop and then holding the sod for two more years. In event the sod held over is largely grass, annual applications of some nitrogen carrier will also be desirable.

In order to fit well into a strip crop arrangement 4- or 6-year rotations are usually more desirable than shorter ones. Due to the present low productivity level of many eroded areas it is difficult to get a good stand of meadow, and one hesitates to hold it for four years as meadow or pasture. However, once satisfactory meadows are obtained the longer rotation has much in its favor for erosion control.

Strip Cropping

Much can be accomplished in the way of erosion control through the wise choice of a rotation and the proper use of lime, fertilizer, and other good farm practices. However, with all of these there may be severe erosion losses due to the movement of water across land in cultivated crops. One effective means of reducing this loss is strip cropping. This consists of growing cultivated crops in narrow strips on the contour across the slope and alternating with hay or small grain crops as indicated in Figs. 18, 20, 24, and on the front cover. With such an arrangement, the cultivated slope is so short that the runoff is never great, nor can it make a current that can pick up much soil. When the runoff strikes the sod area it is slowed down and its load of soil is dropped. There is the further

advantage of reducing the up-and-down hill driving in seedbed preparation and cultivation.

Strips	*Field I*	*Field II*	*Field III*
1	Corn	Grain	1st year meadow
2	2d year meadow	3d year meadow	4th year meadow
3	Corn	Grain	1st year meadow
4	2d year meadow	3d year meadow	4th year meadow
5	Corn	Grain	1st year meadow
6	2d year meadow	3d year meadow	4th year meadow

Fig. 16.—Arrangement of crops of a 6-year rotation in three fields.

A disadvantage frequently mentioned is that it scatters a single crop over too much area and does not permit grazing of meadows. This is only a partial truth. It is possible in most instances to arrange the various crops with a considerable degree of concentration. Taking the 6-year rotation of corn, grain, and four years of sod as an illustration and assuming three separately fenced areas of equal size, we can have in any one year the arrangement of crops indicated in Fig. 16. By this arrangement all the corn comes in one field and all the grain in another. This leaves a third field which may be used for hay or pasture as needed. The second field would also be available for pasture following grain harvest. Somewhat the same sort of arrangement is indicated in Fig. 17, with two fields and a 4-year rotation. A temporary electric fence is a further and an economical means of providing grazing on strip areas.

However, farms generally do not have areas of uniform size and the requirements of the livestock may not permit the use of the most desirable rotation. This means that one's ingenuity will frequently be taxed to devise a satisfactory system. Once worked out it will be worth all annoyance it has caused.

Strips	*Field I*	*Field II*
1	Corn	Grain
2	1st year meadow	2d year meadow
3	Corn	Grain
4	1st year meadow	2d year meadow
5	Corn	Grain
6	1st year meadow	2d year meadow

Fig. 17.—Arrangement of crops of a 4-year rotation in two fields.

If all slopes were uniform, the problem would be fairly simple, but they are not. In fact, few are, and consequently, after two or three strips are laid out they are no longer running on the contour. This may necessitate a very irregular correction strip as indicated in Fig. 18. Here, eight strips running

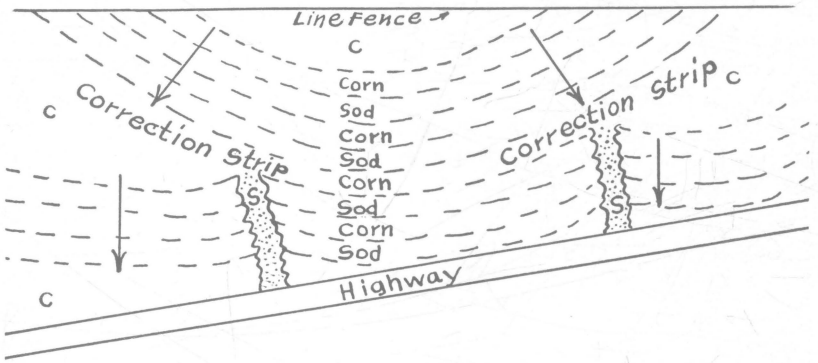

Fig. 18.—An illustration of strip cropping. See text for detail. C—correction areas; S—permanent sod water courses.

approximately on the contour have been arranged. One of these of irregular width is indicated as a correction strip. It may be farmed with point rows when in cultivated crops, or the extra width, like other correction areas indicated by C, may be kept in permanent meadow, being broken only for immediate reseeding with a grain crop. Sometimes such correction areas are quite level and may be used as truck crop areas.

Two permanent sod water courses, indicated by S, are shown in Fig. 18. Here gullies would form should the sod be broken. Orchard grass in combination with timothy is excellent for use in such courses.

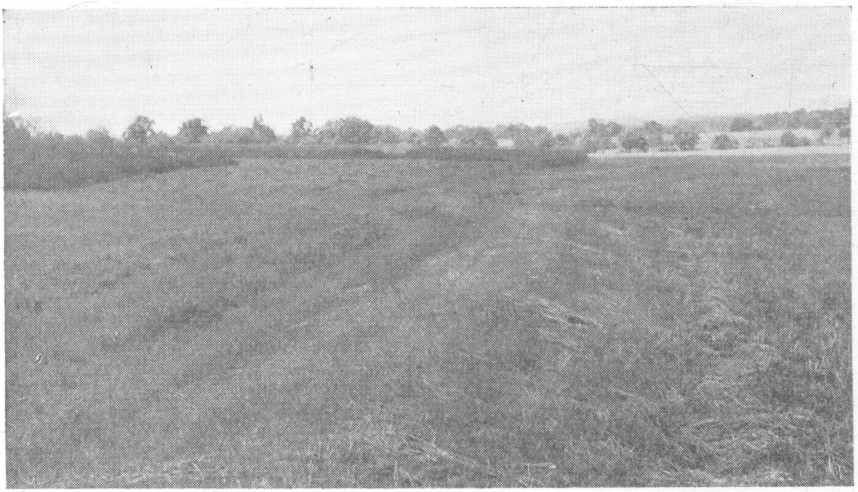

Fig. 19.—A diversion ditch that intercepts the water from the upper part of the slope, and deflects it into a permanent sod area in an adjoining field. This protects the strip crop areas further down the slope.

Fig. 20 illustrates a little different type of problem. Here the topography of the field permits the continuation of the strips into a horseshoe effect. Due to the greater length and the lesser degree of slope on the point of the hill each strip becomes wider at that point, thus necessitating extra short rows or sod areas as indicated by corrective area *a* and *b*. Since this field is adjoined by other fields on the same farm the division fences may be moved and made to conform to the lower boundary of strip 5, throwing *c* and *d* into the permanent pasture area adjoining. The difficulty of building the fence on a curve is recognized and because of this some may prefer to also hold *c* and *d* as permanent hay areas. However, the fence may frequently be made to more nearly conform to the contour without greatly increasing the number of angles or corners in the line.

Table 3. Guide for Laying Out Strip Cropping

Percent slope	Width of strip
Less than 4	112 ft.
4-8	98 ft.
8-12	84 ft.
12-15	70 ft.
15-18	56 ft.
More than 18	42 ft.

The width of strips to use will depend chiefly on the slope, but soil types and degree of fertility also should be considered in determining width of strips. Since soils of low fertility erode more readily and lose their water more rapidly in surface runoff, they should be handled in narrower strips than soils of high fertility. Likewise, soils of sandstone and shale origin erode more readily than those of limestone origin and should, therefore, be laid out in narrower strips. As a general rule, however, it is suggested that slopes of 12 per cent be laid out in 84-foot strips, and that 4′8″ be deducted for each 1 per cent increase in slope. The guide table at left is built on that basis and is believed to be well suited to Ohio conditions.

Frequently it will be desirable to adjust the width of strips in order to accommodate a certain number of corn rows or drill widths. This, of course, varies with different farms. In Table 3 the widths of strips indicated will accommodate corn rows 3½ feet apart, the 42-foot strips providing for 12 rows and the others in order, for 4 additional rows each over the next narrower strip.

Permanent Sod Water Courses.—Wherever there is a tendency for the flow of water down a slope to concentrate in more or less definite water courses, these areas should be maintained permanently in sod (see Fig. 19). When the land is being plowed or cultivated, the plow or other tillage tool should be prevented from disturbing the sod at such locations. There is a common tendency to leave such sod strips too narrow. It is advisable to leave a few feet more than there appears need for. Orchard grass, brome grass, and Reid Canary grass are good species to encourage in such locations.

Another type of permanent water course is the diversion ditch. This is a device to shorten long slopes and carry the water in the diversion channel nearly on the contour to some more favorable location where it may descend with less damage. Such ditches usually empty into woods, permanent pasture areas, or well protected water courses. They may be placed along the upper boundary of a crop field or at one or more places through the field, depending upon the length of slope. While these resemble terraces in some respects they are usually steeper and less expensive structures, and are kept permanently in sod. They should be given careful consideration in the laying out of lands for strip and contour farming.

Laying Out Land for Strip Cropping.—In laying out any field or land for strip farming, the suggestions in the paragraphs following should prove helpful.

1. Mark out a line straight up the slope near center of field, or at a position of about average slope. For convenience, call this line AA (Fig. 21). Mark its position with at least two stakes, one near the bottom and one near the top of slope.

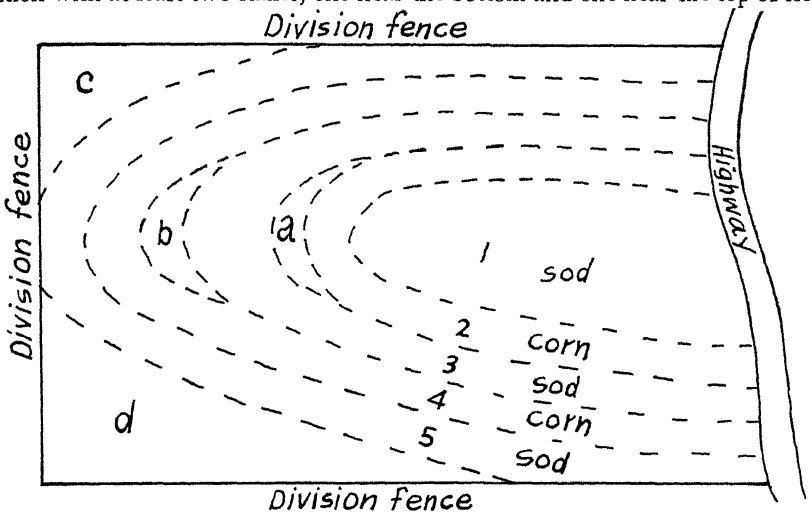

Fig. 20.—A strip crop arrangement of many eastern Ohio farms. (See text, page 20.)

2. Determine the average percentage of slope along this line. This is the number of feet of fall in 100 feet of slope. A hand level graduated to read in percentage of slope is convenient for this purpose, but it also can be determined easily by an ordinary carpenter's level.

3. From the guide table and other information on previous pages, select the proper width of strip for this slope.

4. Measure the length of slope along line AA.

5. Determine the number of strips to be laid out. It may be necessary to vary somewhat the actual width of strips as shown in Table 3 to avoid fractional strips, or to adjust the number of strips to various rotations or convenience of handling the crop.

6. Mark with stakes the strip divisions along the line AA. Remove any other stakes previously set to mark line AA.

7. After a careful inspection of the area, select a stake along AA for the location of a base contour or strip division line. This may be the stake

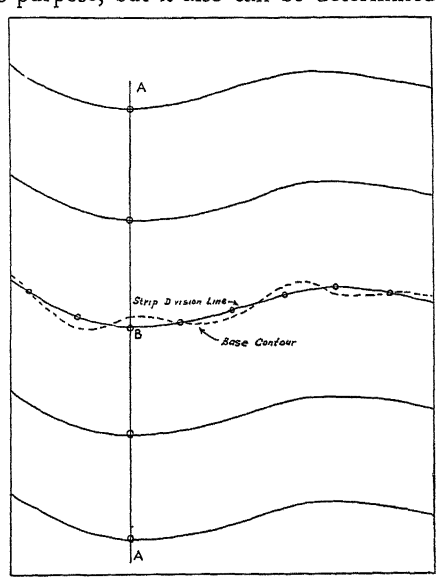

Fig. 21.—This illustrates a method of laying out a system of strips for strip cropping. See text.

Fig. 22.—A Suggested Procedure in Establishing Strip Cropping

Field	1941	1942	1943	1944	1945
1	Corn	Wheat—green manure	Corn	Wheat	1st year meadow
		Wheat—meadow	1st year meadow	2d year meadow	Corn
		Wheat—green manure	Corn	Wheat	1st year meadow
		Wheat—meadow	1st year meadow	2d year meadow	Corn
2	Wheat	1st year meadow	Corn	Wheat	1st year meadow
		1st year meadow	2d year meadow	3d year meadow	Corn
		1st year meadow	Corn	Wheat	1st year meadow
		1st year meadow	2d year meadow	3d year meadow	Corn
3	First Year Meadow	2d year meadow	3d year meadow	Corn	Wheat
		Corn	Wheat	1st year meadow	2d year meadow
		2d year meadow	3d year meadow	Corn	Wheat
		Corn	Wheat	1st year meadow	2d year meadow
4	Second Year Meadow	3d year meadow	4th year meadow	Corn	Wheat
		Corn	Wheat	1st year meadow	Wheat
		3d year meadow	4th year meadow	Corn	2d year meadow
		Corn	Wheat	1st year meadow	2d year meadow

most centrally located along AA, but frequently better results can be obtained by shifting to the top or bottom of the slope, or even some other intermediate stake as a starting point.

8. Starting at such a stake, marked B in Fig. 21, lay the base contour. This may be done by use of hand level, carpenter's level on a staff, or surveyor's level. Stakes should be set along this contour at intervals of 50 feet or less. Closer spacing of stakes will insure greater accuracy.

9. On irregular slopes the base contour will be quite an irregular line. Give a smooth curve to the line by moving some of the stakes from their original position. Maintain the mean contour in smoothing out sharp curves by moving part of the stakes up slope and part down slope.

10. Locate the next strip division below the base contour by measuring directly up or down the slope from each stake a distance equal to one strip width.

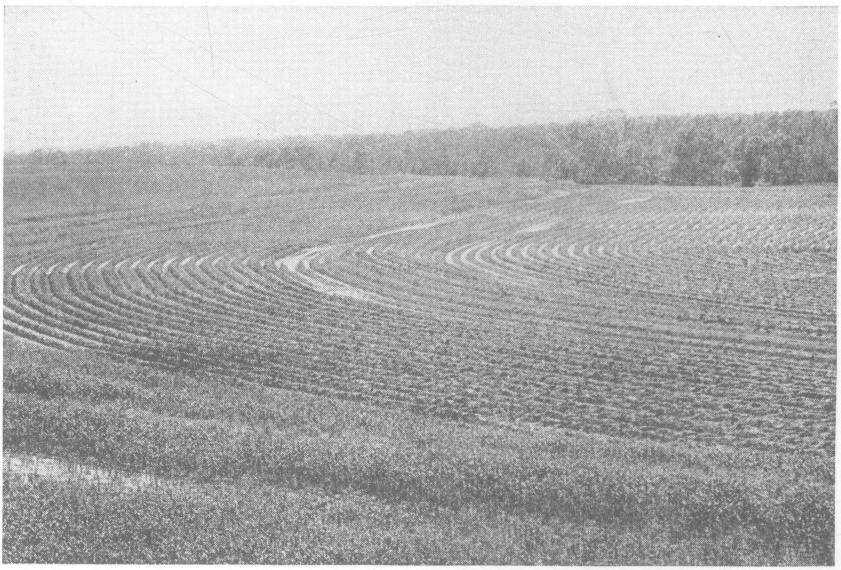

Fig. 23.—Arrangement of rows on the contour may prevent 50 per cent or more of the soil and water losses. Note the water standing between rows. (*Soil Conservation Service.*)

Mark these positions with stakes, or still better by means of a plow furrow made at the time of measuring. Locate other strip divisions in like manner.

11. When measuring more than one strip division from a base line, each one should be checked to determine how much it varies from the true contour. If the variation is sufficient to give a grade of 3 per cent or more in a direction parallel to the strip division line for more than 30 to 40 feet, a correction strip should be inserted in order to keep other strips regular and reasonably near the true contour (see Figs. 18 and 20).

Getting the Plan in Operation.—When putting the strip cropping plan into operation avoid any arrangement that will, once the system is established, permit corn or other cultivated crops and wheat or other small grain crops coming in adjoining strips. This is not always possible during the first few

years when the plan is in process of establishment or in event of crop failures, but generally such an arrangement can be maintained.

There is also the problem of how to arrange the crops in order to get the plan into operation. To illustrate, let us assume that there are four fields each to be stripped and that the four fields are now respectively in corn, wheat, first year hay, and second year hay. A suggested procedure is outlined in Fig. 22.

In order to get the plan in operation, it will be necessary to hold one meadow for four years and two others for three years, but by 1945 the plan will be in full operation with 1- and 2-year meadows only. Furthermore two fields are so arranged that they may be used for pasture following wheat harvest if needed for that purpose.

Contour Cultivation.—The practice of cultivating sloping land on the contour was one of the earliest erosion control measures used in this country. The

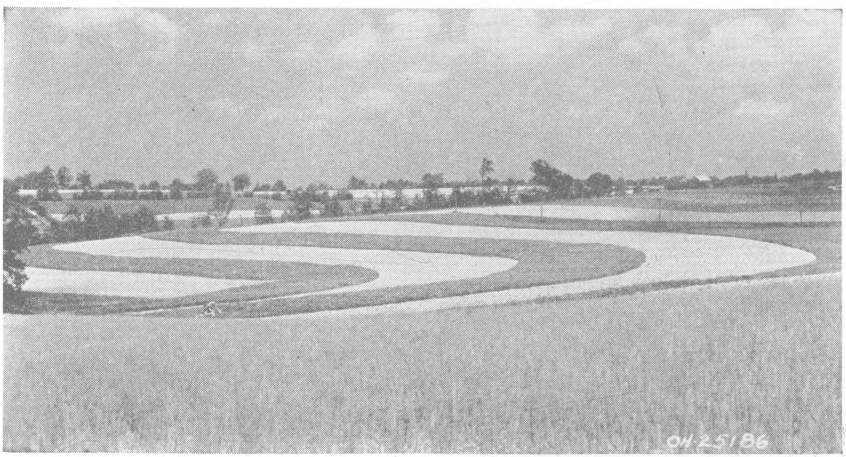

Fig. 24.—Strip farming in a rotation of potatoes, wheat, and 2 years of hay.

practice alone is ineffective, unless the soil productivity is maintained at a high level and good stands of legume-grass mixture occur often in the cropping plan.

Some slopes are too variable to make strip farming practical. Under these conditions it is frequently still possible to keep the seedbed preparation and cultivation approximately on the contour and it is always possible to give additional emphasis to the fertility level and the quality and amount of sod in the rotation, both of which are very effective in erosion control.

Erosion Control in Potato Farming

Due to the high cash value of the potato crop and its particular soil requirements, this crop is commonly grown in short rotations. Most common of these are:

1. Potatoes — grain (clover for cover and green manure)
2. Potatoes — (rye, soybeans and rye in succession for cover and green manure)
3. Potatoes — (rye, corn and buckwheat and rye in succession for cover and green manure)

With these 2-year rotations, although the fertility is maintained at a high level, the frequent breaking and cultivation gives ample opportunity for erosion, especially in rotations 2 and 3.

In some sections of northeastern Ohio, where late potatoes are commonly produced, erosion has become serious. Lengthening of the rotation would be of great help in reducing this erosion, but usually in longer rotations the fertility level is not properly maintained, since such a high production is not so essential to other crops. It frequently happens that other areas of the farm have not or cannot readily be adjusted to a desirable soil reaction level for potatoes. Where other areas do have proper fertility levels and a suitable reaction the longer rotation is recommended.

Strip cropping and contour cultivation naturally have the same advantages with potatoes as with other crops (see Fig. 24). Sod buffers or strips of sod between cultivated areas of several years' duration have the disadvantage of harboring wireworms.

Terracing on longer slopes, especially on the upper part, has possibilities, and should receive consideration. Diversion ditches, designed to divert the runoff water from the potato area, can also be used to advantage. The high cash value of the crop well justifies the extra expense of such measures to carefully protect the crop and conserve the soil.

Another worthwhile caution is always to harvest the potatoes as soon as possible, so that small grain may be seeded for winter protection.

Gully Control on Crop Land

Gullies are the ultimate outgrowth of sheet erosion. It is much easier to prevent the development of gullies than to remedy them after they are established. Surface drains or low areas by which the runoff water leaves a slope should be kept in sod at all times (see Fig. 18). Orchard grass and brome grass are valuable plants that should be added to ordinary seed mixtures for use in such areas. While the practice of leaving these "drains" unplowed is more or less common, too frequently the plow is not raised soon enough and a gully starts along the side of the old water course. If the edge of the sod strip is kept irregular by raising the plow at a different point each successive time, this secondary wash is much less likely to form. If proper precautions to prevent sheet erosion on the balance of the field are taken and these water courses are properly cared for, gullies are not likely to develop.

Where gullies have already formed, steps should be taken at once to prevent their doing further damage. The first step is to find some way of reducing the flow of water in the gully channel, or build structures that will keep the water that must flow in the channel from washing out the new seeding that will need to be made in the channel bed. A good time to work on gullies is when the field is in sod, since there will be less flow of water at that time. Late summer or fall are preferable periods of the year for the same reason.

Temporary diversion ditches made by plowing one or more furrows, herring-bone style, about the head of the gully and carrying the water out on to good sod, where it may descend by a different course, will be found helpful.

Such diversion ditches should have enough slope (generally not more than 3 per cent) away from the gully to carry the water but not enough to start washing.

When provision has been made for temporary control of this surplus water, the gully may be prepared for seeding by plowing in the banks, smoothing the soil with a harrow, liming if needed, and treating with 1 pound of fertilizer such as 4–16–4, per 80 square feet, or approximately 500 pounds per acre. The fertilizer should be incorporated and the soil worked down to a firm seedbed, when a seed mixture should be applied at the rate of about 1 pound to each 1000 square feet and lightly covered. A good seed mixture for use on such areas consists of 6 parts orchard or brome grass, 4 parts timothy, 2 parts red top, 5 parts alfalfa, and 3 parts alsike.

Where the seeding is made later than September 10, a light seeding of a companion crop, such as rye or wheat, should be used with the grasses and the legume seeding held over until spring.

In most cases a light mulch of manure or other organic matter after seeding is desirable. These rather liberal applications of fertilizer, seed, and manure are justified, since this is permanent crop land from which high production is expected and where heavy sods are necessary to stand the effects of future floods. Once the new sod is established, the runoff may be permitted to assume its original channel, but the channel should never be plowed again.

Where the drainage area feeding the gully is large, a permanent sodded diversion ditch which will carry the water out into a pasture or timber area is frequently advisable. Care should be taken to see that such a ditch is large enough to take care of the most intensive rains and that the outlet is properly protected. Otherwise another gully may result.

Where the water draining into a gully cannot be diverted and is sufficient in volume to remove the soil plowed in for closing the gully, some temporary structures are necessary. These should be not more than 18 inches high and so placed that there is not more than a 2 per cent grade from the top of one to the bottom of the next one above. These structures may be made of brush, logs, sod, slabs, or other material.

Fertilizer bags filled half full of soil make efficient check dams. A little seed of the mixture suggested for gullies should be mixed with the soil next to the top side of the bag when it is in place. One or two bags at a place are usually better than more. Never build temporary check dams high, since if this be done a new break and a restarting of the gully will result in a few years when such a dam gives way. Such temporary dams having been provided, the gully may then be prepared and seeded as previously indicated.

Occasionally, a more permanent type of dam will be necessary. In such case it should be well built and set so deeply into the sides of the gully that there is no danger of water cutting around it. It must be deeply notched at the top so that during the heaviest rains water will not overflow and cut a new channel at one side. The lower side of the structure must be well protected by large rocks, concrete, or other material that will prevent the dam being undermined.

In conclusion, it is well to remember that gullies represent an advanced stage of sheet erosion, and that sheet erosion results from improper farm practices. Control sheet erosion and there will be little trouble with gullies.

Terraces

Terracing is a new farming practice in Ohio, but in some sections of the country it has been used for erosion prevention for many years. Terracing consists of a series of broad ridges constructed across the slopes more or less at regular intervals to carry away the runoff water. On the upper side of each ridge there is a broad, shallow channel with a slight grade toward an outlet. The terrace catches the runoff water before it attains sufficient velocity to cause serious erosion, and carries it slowly toward the outlet (see Figs. 23 and 25).

Lands Adapted to Terracing.—Terraces are particularly adapted to long regular slopes where there is considerable concentration of runoff. On these

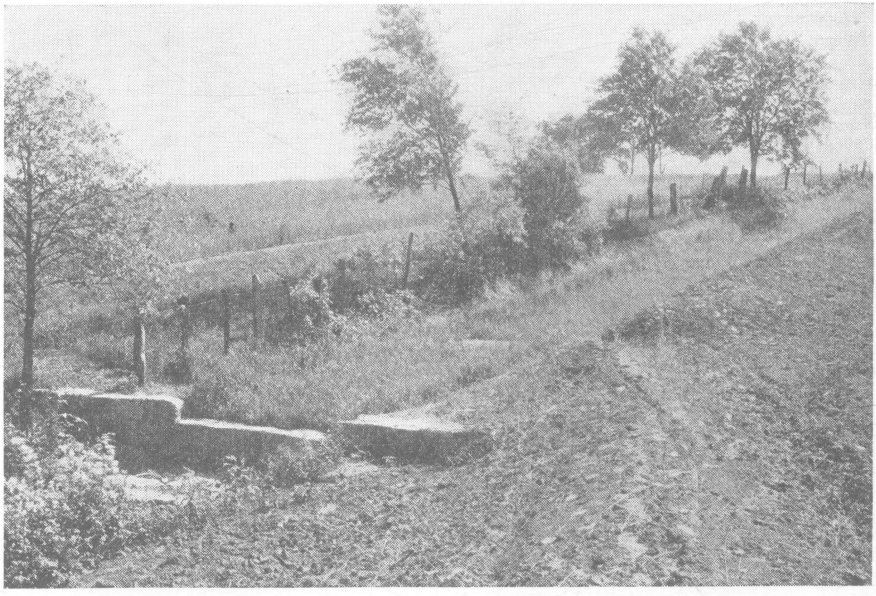

Fig. 25.—A well protected terrace outlet is an essential of successful terracing. *(Courtesy Soil Conservation Service.)*

slopes it usually will be found most advantageous to terrace only the upper part of the slope. In this way the amount of water flowing over the lower part of the slope is greatly reduced. The terraces furthermore serve as an excellent guide row for contour cultivation.

Terracing should be confined to slopes not steeper than 10 percent, and generally of less than 8 percent. Fields considered for terracing should be of sufficiently smooth and uniform slope to make unnecessary sharp bends and turns in the terraces, which give difficulty in the use of teams and machinery working on the contour or with the line of the terrace (see Fig. 23).

Terracing should also be limited to areas where rock or shale is not within 4 feet of the surface. While terracing does not at present have a wide application,

there are areas in various parts of the state, especially in the southwest, where it should be considered. It is not a substitute for other methods of erosion control but a supplement to them. Neglect of other factors may render the terraces worthless.

Terrace Outlets.—In considering fields for terracing, careful consideration should be given to selection of an adequate outlet. The outlet must be able to withstand the concentration of water from all the terraces, otherwise gullying will occur, which may be worse than if no terracing were done. There is no part of the terrace system more important than the outlet, and failure to construct it correctly and carefully is ruinous. The most desirable practice is to build the outlet and let it become thoroughly sodded before the terraces are constructed. Those interested should refer to special terracing bulletins for details of construction (see Fig. 25).

Laying Out and Constructing Terraces.—Before terraces are built they must be properly laid out. This is done with a drainage level or with a farm level. Terraces are spaced according to the slope of the lands, the type of soils, and the kind of crops grown. The following table indicates briefly the spacing for various slopes.

*Table 4.—Terrace Spacing Table**

Slope of land in feet per 100 feet	2	4	6	8	10
Vertical fall between terraces, feet	2¾	3½	4	4¾	5½
Distance between terraces, feet	137	88	67	59	55

Where rotations having more than 50 percent sod crops are employed, and the fertility levels are maintained above the average, and if the soil types are not readily eroded, the vertical fall and distance between terraces may be increased by 20 per cent. Otherwise, it is important to follow this table rather closely in choosing the proper spacing. Terraces also should be given the recommended grade. For Ohio conditions, a grade varying from 1-inch fall per 100 feet near the upper end of the terrace, to 4 inches fall per 100 feet near the outlet, will be found generally satisfactory. The grade of terrace should never be more than 6 inches to 100 feet.

There are many methods and types of equipment used in constructing terraces. However, the most common machines are those resembling road graders. In fact, many farmers have used small road graders to build terraces. The smaller outfits may be pulled by horses, but the larger ones require tractors. The cost of terracing varies with the type of equipment and efficiency of the operator. With four horses and a small terracing machine a farmer can terrace about 3 acres per day, while with a larger outfit, such as a 40 h.p. tractor, and a 10-foot blade terracing machine, about 10 acres per day can be terraced. For the larger equipment, the cost per acre will vary from $1.50 to $3.00 per acre plus the cost of the outlet construction. The terraces are usually made about 30 feet wide so as not to interfere with the use of ordinary farm machinery.

*Compiled by C. E. Ramser, Soil Conservation Service.

New terraces are constructed so that they are 18 inches to 20 inches high, but when they have settled they will only be from 12 to 16 inches in height.

Farming Terraced Land.—Farmers who have never done terracing are often puzzled about how to farm their terraced land. The best practice is to do as much farming as possible parallel to the terraces. Farmers who have not followed this advice have found that the terrace ridge is quickly destroyed by the farm machinery continually crossing the ridge. The ridge of the terrace is easily maintained in the plowing operations. Every time the field is plowed the terrace ridge should be back furrowed, throwing the dirt toward the center of the ridge. If this procedure is followed, and the farming operations are carried on parallel to the terraces, no further maintenance will be necessary. Where strip cropping accompanies terracing, the ridge of the terrace should be made the center of the strip.

Fig. 26.—An excellent blue-grass-white clover pasture, treated and well managed on a Jackson County farm, offers little opportunity for erosion. This land which was once used for crops is now devoted to a better adapted use. Pasture should carry more of our livestock load.

EROSION CONTROL ON PASTURE LAND

Experimental evidence obtained in recent years has shown clearly the great value of pasture sods in controlling moisture and soil losses. Average to good pasture sod compared to cultivated crops on various slopes reduces the loss of moisture 20 to 30 percent and practically prevents the loss of soil. Runoff occurs on good pastures only during heavy rains or when the soil is saturated and, since the retention of moisture is increased 20 to 30 percent over cultivated lands in heavy rains, the total saving of moisture on pasture areas may well amount to the equivalent of 7 to 12 inches of rainfall in a year.

Good pasture vegetation holds the soil, decreases the velocity and movement of water on slopes, and increases the soil's organic content (see Fig. 26). This increase of organic matter further adds to the soil's absorptive and moisture holding capacity, decreases erosion, and raises the production level. For a more detailed discussion of pastures the reader is referred to Bulletin 154, entitled "Better Pastures for Ohio Livestock," issued by the Agricultural Extension Service of The Ohio State University.

Class A Pastures.—This class of pasture includes those where 70 percent or more of the ground is covered with a good quality sod consisting chiefly of Kentucky bluegrass, red top, and white clover.

Under these conditions very little erosion is taking place, and no further fertilizer treatment is justified for erosion control (see Figs. 26 and 27).

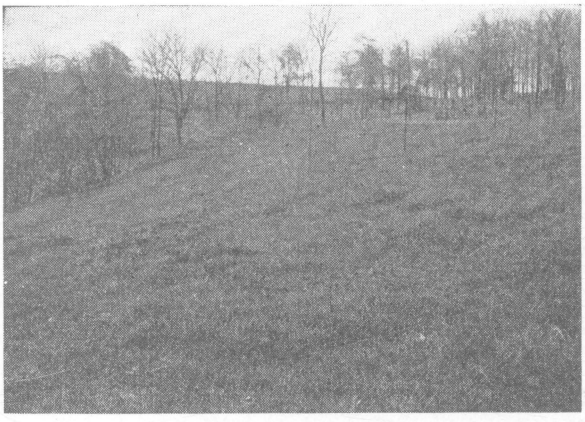

Fig. 27.—Erosion is not a problem where a good pasture sod is maintained. This pasture was improved without plowing.

Class B Pastures.—This class includes those pastures where less than 70 percent of the ground is covered with vegetation, where the clover content is low, and where red top, Canada bluegrass, poverty grass, cinquefoil, and other poor land plants have superseded Kentucky bluegrass. Where this condition exists on sloping lands erosion is generally a problem, and investigation is likely to show that 25 to 90 per cent of the surface soil has been removed. Under these conditions immediate treatment is necessary to save the soil.

Class C Pastures.—Where less than 25 percent of the ground is covered with vegetation and where 90 percent or more of the vegetation consists of

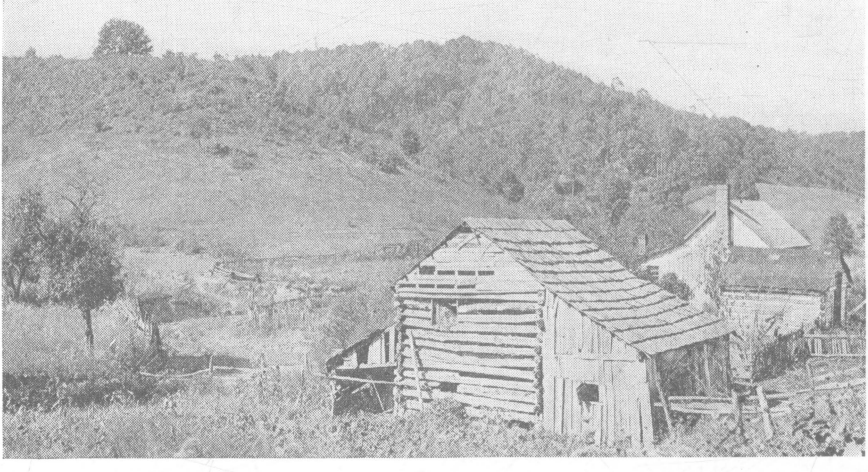

Fig. 28.—Nature is attempting conservation of this rundown farm by starting a growth of brush on the eroded and neglected pasture. Farming without erosion control leads to farm abandonment.

poverty grass, bracted plantain, broom sedge, and briars, the condition is critical. Where this condition exists on land of 5 percent or more slope, inspection of the soil is likely to show more than 90 percent of the surface soil removed. Such areas frequently give little return on the investment from the point of view of increased production. Such areas may well go into farm woods regardless of slope (see Fig. 28). There are many cases, however, where some such land must be included in the pasture area.

Treatment of Permanent Pastures

The plowing of old pasture areas on sloping land for the purpose of improving them may result in the washing away of much of the surface soil, leaving the raw subsoil on which the establishment of a profitable pasture is very difficult. There are cases, however, of gentle slopes and level land where comparatively little danger of serious erosion exists. Under such conditions where the grass is badly runout, where weeds are a serious problem, or where poverty grass forms such a heavy sod that fertilizers cannot be incorporated, plowing and re-establishing may be justified. But even here, unless the weed content is very high, disking is likely to be preferable to plowing (see Figs. 7 and 27).

Generally, therefore, the treatment should be the required amount of lime and 400 to 500 pounds of 0–20–0 or 0–14–6 fertilizer per acre, applied to the sod. The lime application may be made on the surface, and the fertilizer by means of a disk drill cutting ½ to 1 inch deep and running on the contour. On very thin sods and on "galded" spots where erosion has been severe and where the soil dries out rapidly, manure or other form of organic matter is necessary to satisfactory improvement.

Manure is of an immediate benefit in that it checks runoff, rate of evaporation, and erosion, thus conserving the necessary moisture and nutrients for the development of a better sod. It also supplies extra nutrients and for a time protects the vegetation from grazing.

On slopes where plowing seems necessary, improvement can be accomplished with less danger of erosion if the plowing is done in narrow strips on the contour and several years used in improving the entire slope. Thus one strip is reestablished in sod before another is broken. (For details of pasture improvement see Extension bulletin 154, "Better Pastures for Ohio Livestock.")

The Grazing and Care of Permanent Pastures

Regardless of how well permanent pastures are limed and fertilized, satisfactory erosion control sods will not develop, nor can such a sod be maintained, unless careful attention is given to care and management. Experiments have shown variations of several hundred percent in the amount of improvement obtained from like treatments but where grazing has been different. The same grazing practices which produce the maximum yield of the most nutritious herbage are probably also the ones that develop the sod best able to resist erosion. The ideal seems to be so to graze that the vegetation may be kept at a height between 1½ and 5 inches. This condition can probably best be obtained by alternate or rotational grazing.

If the vegetation can be maintained at the heights indicated, it is likely to develop rapidly into a closely knit, well balanced, white clover-bluegrass sod — very efficient in erosion control. Particular care should be taken not to over graze in late fall, winter, very early spring, or in July and August, since such a procedure is likely to greatly damage both grass and clover and leave a very thin sod of low production value and an exposed soil subject to serious erosion.

Special Treatment for Badly Eroded Areas

In many pastures are certain areas of badly eroded land such as are described in Class C pastures. Even though of doubtful value for pasture, the

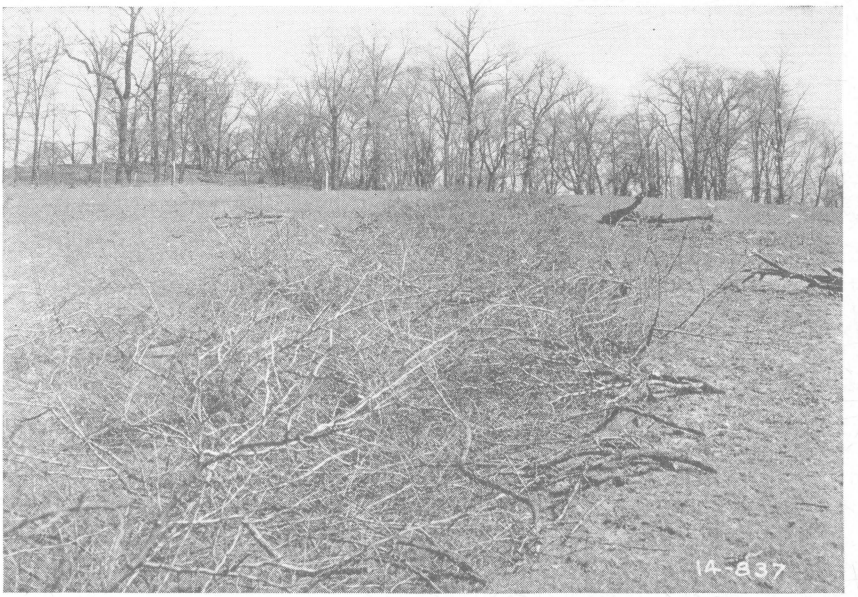

Fig. 29.—A light cover of brush on a reseeded sheet eroded or gullied area has been found effective in protecting it from livestock until the new sod is established. *(Courtesy Soil Conservation Service.)*

cost of excluding them makes it necessary that they be retained in pasture. Under such conditions there are several possible procedures. First of all, there is the possibility of manuring, liming, fertilizing, and reseeding as previously described and then covering with brush to provide protection for a few years. The brush should not be thick and is best of a thorny type (see Fig. 29). Where the soil has a good lime content or where lime has been abundantly supplied, sweet clover may well be added to the seed mixture.

A second possibility is to use a liberal lime application but a comparatively light fertilizer application, consisting of 200 to 300 pounds per acre of 20 percent superphosphate or 0–14–6, then seeding to sweet clover alone and providing a

temporary fence that will exclude livestock for several years. This results in the improvement of the physical condition of the soil and the building up of the available nutrient content. With this condition, a good type of grass and legume sod gradually develops. Seeding may be made alone or with a grain companion crop. When sweet clover is seeded in the fall or winter, 30 pounds of seed in the hull may be used to the acre. When seeded in the spring, 12 pounds of inoculated scarified seed should be applied between March 15 and April 1.

In any case, some preparation of the seedbed is necessary, and some light mulching after seeding is desirable.

Gully Control in Pasture Land

Where gullies are not severe, they frequently will take care of themselves with the general improvement of the pasture. Where more pronounced, they

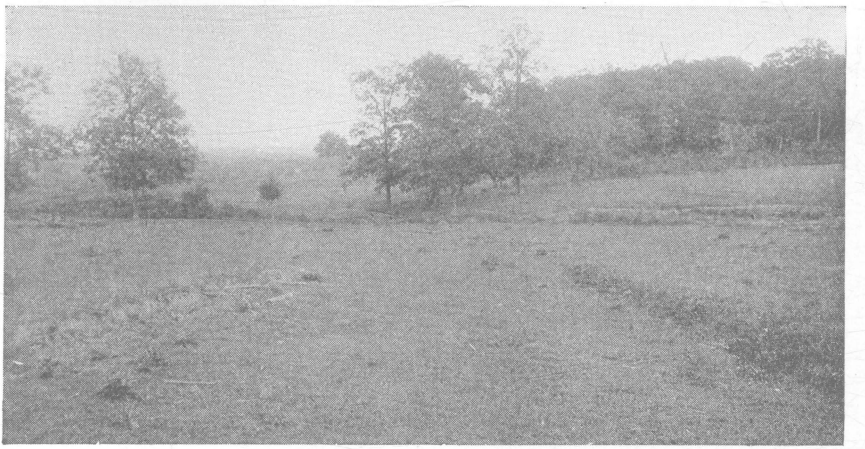

Fig. 30.—The remains of what was at one time a serious gully. The original rims are shown at the right and left, the left being now almost entirely obscured by growth. The gully was closed by temporary obstructions and good sod protection.

demand some individual attention. The first step is to provide some temporary way of controlling the water until a sod can be established in the gully. This may be done by sod, wire, brush, slab or low stone dams, or by diversion ditches which will carry the water out on to well sodded areas for a few years or even permanently.

After some temporary provision has been made to prevent further washing, the gully banks should be graded back, limed as needed and liberally fertilized and seeded after the manner described for badly sheet eroded areas. Orchard grass, however, should always be included in gully seedings. The planting of locust trees is also frequently advisable. The temporary exclusion of livestock by the use of brush (see Fig. 29) or by fencing is necessary to the development of a good sod in gullied areas. Once a good sod is provided and properly cared for, no further trouble is likely to be experienced (see Fig. 30).

EROSION CONTROL ON ORCHARD LAND

Many orchards are planted on high elevations and hillsides to provide good air drainage. The use of sloping land, particularly where the orchard is cultivated, has resulted in enormous losses of soil from erosion in some orchards. Ohio apple orchards can frequently be maintained fairly constantly in sod with mulching, but this is not true of peach orchards, vineyards, bush and cane fruit plantings. Where such fruits occur on sloping lands some means for erosion control must be employed.

Among the various means worthy of consideration are contour planting, terracing, sod or buffer strips on the contour, mulching, contour cultivation, making use of sod or other crops whenever possible, and the various means of gully control. In orchards where cultivation is necessary sods may be maintained in alternate middles for one year at a time.

Contour Planting

This method consists in planting the trees or other plants in rows on the contour rather than in straight lines. When planted in this manner it is not always possible to keep the rows and plants the same distance apart, but this is not significant compared with the advantage of being able to cultivate and work on the contour. Where established orchards are involved this is not so easy, but even then some trees may well be removed and cultivation be permitted to cross from one tree row to another in order to keep as nearly as possible on the contour.

Terracing

Where the plantings have not been made it is possible to build the terraces and then set the trees just below terrace ridges. This is especially desirable for the upper part of long slopes, thus cutting off the surplus water that would otherwise flow across the land farther down the slope. The lower portions of the slope may be planted on the contour without terraces (see Fig. 31).

Another very distinct advantage in terraces is to provide for irrigation. The water may be pumped into the high end of the terrace channels at such a rate that it will gradually work to the far end and be absorbed on the way, thus letting no surplus run out. Temporary obstruction of the outlet will also help in bringing about complete percolation of the water into the soil.

Where orchards are already planted it is still sometimes possible to establish terraces with the removal of a few trees. Where erosion is a serious problem this is entirely justified. Cultivation, naturally, would be on the contour with the terraces. The importance of properly constructed and protected outlets cannot be over-emphasized.

Buffer Strips

Buffer strips of sod running with the tree rows across the prevailing slope are very effective in erosion control. Another means of using buffer strips is to alternate strips of sod and cultivation, and then change the sod to cultivation and the cultivation to sod every 2 or 3 years. In this manner half or two-thirds of the area may be kept in sod at all times. If these sod strips are composed of large type legumes and the coarser grasses, and are mowed at times when the

sod might otherwise be competing with the trees for moisture and nutrients, and the clippings are left in the orchard for mulch, this system can be made to work very nicely. Clippings give best results when placed under the branch spread of the trees, but even then they are not likely to supply sufficient mulch and should be supplemented by additional material hauled in.

A good seed mixture for use in establishing such buffers consists of 8 pounds alfalfa, sweet clover or red clover, 2 to 3 pounds alsike clover, and 4 pounds timothy or 7 pounds orchard grass seeded with 1 bushel of winter wheat early in the spring. At the same time such lime as is needed and 300 pounds of 0–14–6 should be used. Alfalfa is deep rooted and draws moisture from the same zone as the tree roots. It is very important, therefore, that it be kept in check during periods when the moisture supply is limited. It has the advantages over a longer period of increasing both the nutrient and moisture content of the soil and of improving its physical condition.

Korean lespedeza seeded at the rate of 12 pounds per acre early in the spring alone or in combination with 4 pounds of timothy is another splendid orchard cover crop for use in such buffers or for solid seedings. Its shallow roots do not compete with tree roots, it reseeds itself every year, and is adapted to thin land subject to erosion. While it is an excellent crop with which to begin a program of erosion control and improvement in the orchard, its long time effects are not so good as the larger legumes. Eventually, it should be replaced by other legumes that will provide sod in winter as well as summer.

Still another possibility is to provide buffer strips entirely of mulch. In the case of strawberries and other small fruits that are regularly mulched, this practice is very effective. In the case of larger fruits the mulched strips may alternate wth cultivated strips from year to year.

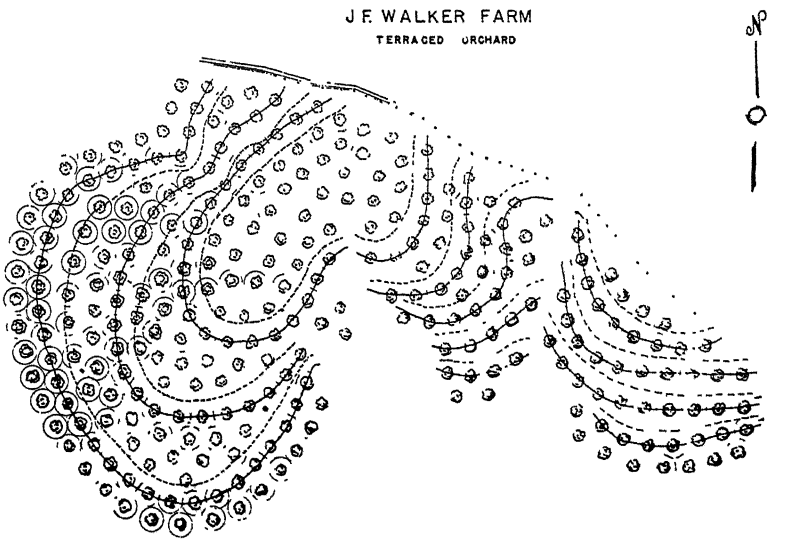

Fig. 31.—A plan of terracing and tree arrangement for an orchard on hill land.

Fertility Level

Another effective erosion control measure is to maintain a high fertility level. Productive soils carrying a good organic content will not erode half as fast as depleted soils. Since trees can draw much nutrient material from the subsoil, the fertility level of the surface soil is frequently neglected. This is a very serious error from both the erosion and long time production points of view. Sufficient lime and fertilizer should be applied to keep the soil in condition for the production of a good growth of clover, alfalfa, and other legumes used for erosion control, green manure, and mulch crops.

Regardless of the type of fruit, there is usually a time when such crops can be grown without competing seriously with the fruit for moisture and nutrients, and they are essential to a long time production program and the conservation of the soil.

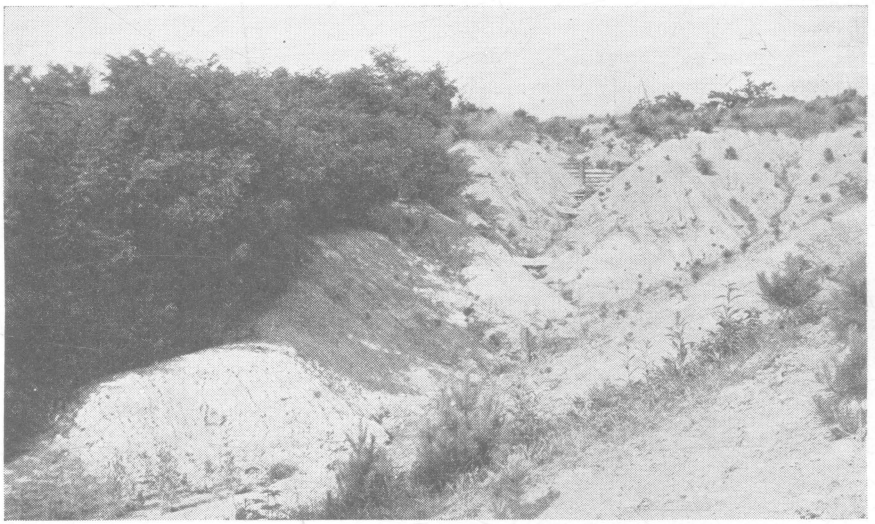

Fig. 32.—This picture, taken in 1937, shows a badly gullied area in Muskingum County. The left half was set to locusts and the right to pines in 1934. At the time of setting the trees the area now completely obscured by the locusts was gullied even more than that occupied by the pines.

EROSION CONTROL AND THE FARM WOODS

While planting steep and rough lands on the farm to farm woods is the first step for erosion control on such areas, there are yet other things with reference to these woods that must be considered if control is to be satisfactory.

Effect of Pasturing the Woods

Even if erosion control were not considered, it is improbable that the pasturing of the farm woods, as shown at left in Fig. 33, would prove profitable. Pasturing kills out the seedling growth and destroys the leaf litter. Both of these are essential to the future growth of the woods and the conservation of the soil.

The best plan is to exclude livestock from the farm woods (see illustration at right, in Fig. 33).

Fire Leaves Soil Open to Erosion

Fire has much the same effect in the woods as pasturing. The chief difference is that the fire is much more rapid in its destructive tendency. In one case the soil organic matter and undergrowth of the woods are gradually destroyed by grazing and trampling. In the other they are quickly destroyed by burning. In both cases the soil is left in an exposed condition subject to severe erosion. Since 90 percent of all forest fires results from the carelessness of man, their prevention is largely under his control. Care should always be used to see that no fire escapes when burning brush, hunting, or camping.

Fig. 33

Pastured
Pasturing kills new seedling growth and destroys leaf litter.

Not Pastured
Protected from grazing, young trees soon become established.

Tree Planting

Steep, rough, and other areas adapted to trees and at present not in the farm woods will, if protected from livestock, gradually reforest themselves. This generally is a very slow process, and may result in the development of weed trees rather than desirable timber trees. In the meanwhile soil losses continue to some extent. Much the better plan generally is to protect such areas from livestock and reset them to desirable species. In badly gullied areas temporary check dams will also prove desirable, and if locusts and other adapted species are used, it will be a matter of only a few years until the new woods has brought soil erosion entirely under control.

Usually in establishing woods areas, trees are spaced 6 feet apart each way or at the rate of approximately 1200 trees to the acre. On the thin sandstone soils preference should be given to pines such as the red, Scotch, and white pines.

Probably red pine is the best all-around tree to plant on badly sheet eroded dry soils, but Scotch pine also is well adapted to such sites. In pine planting, 3- or 4-year-old nursery stock gives best results.

In broken and gullied areas, in limestone sections, and where the subsoil carries a good lime content, black locust should be used in the major portion of the gully. Black locust grows rapidly and develops a root system that spreads out quickly over the eroded area. Where gullies and eroded areas are severe, spacing should be approximately 4 by 6 feet apart, enabling the trees to establish a cover quickly.

Hardwood varieties such as oak, walnut, hickory, ash, and tulip poplar are not adapted to badly eroded, depleted soils but should be planted in the deeper, more fertile soils contained within the erosion problem area. Seedlings of oak, walnut, ash, and tulip poplar may be obtained from the nursery, or the seed of these varieties can be sown or planted directly in the field or woods. Walnuts and hickories have especially deep tap roots and oftentimes are difficult to transplant from the nursery. For this reason collecting the seed and planting directly either in fall or early spring is preferable to the use of seedlings.

When planting the seed, it should be covered to a depth of 1 to 2 inches.

For planting in early spring, the seed should be gathered in the fall and stored outdoors in a pit or trench through the winter season. The seed should be covered with a layer of sand, and this by soil or woods mulch to keep the sand moist. This procedure is known as "stratifying" walnuts or other hardwood seeds.

Wet soils or water pockets should be planted to willows and cottonwood; usually one-year cuttings can be used for this purpose.

A mattock or grub hoe is the most efficient tool to use in planting trees. A bucket containing water may be used to carry the plants when being set, so that they may be kept wet at all times. The hole for the tree should be made large enough to receive the roots without crowding and the soil should be tamped or placed firmly around the roots.

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Management of Farm Woods for Erosion Control

1. Keep livestock out at all times.

2. When removing undesirable growth or timber, cut close to the ground and let tops remain on forest floor to hold leaves in woods. Larger branches and trunks may be utilized for fuel.

3. Leave a fringe or natural "windbreak" growth on west and southwest sides of the forest area. Such a strip or border of natural growth should be 25 to 30 feet wide in order to protect interior of wood from storm damage and hold natural leaf mulch within the wood area.

4. Avoid making large openings in the woods by clear cutting. Use the selection method in cutting trees for saw logs.

5. Leave seed trees of good varieties such as tulip poplar, white ash, white and red oak to reseed the cut area.